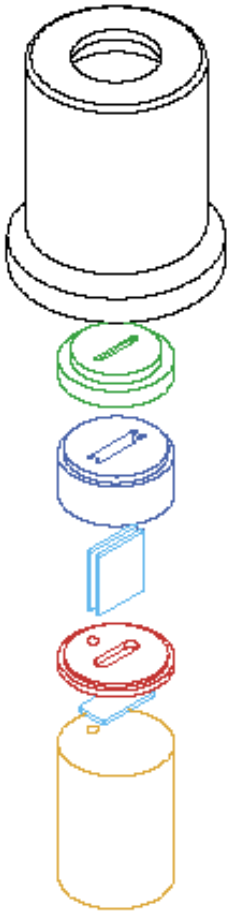
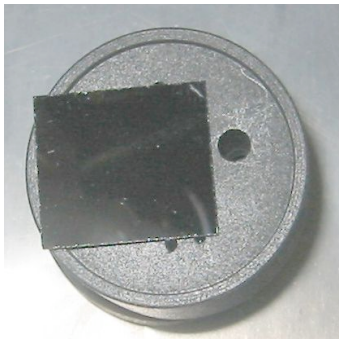
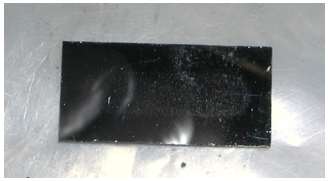
DiMES Tile Gap Experiments







Dmitry Rudakov (UCSD)

for the DiMES Team

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An ongoing international multi-institutional effort

Experiment originally proposed by Wolfgang Jacob

Max-Planck-Institut fuer Plasmaphysik, Germany

People involved in sample design, planning and performing experiment, analysis of results and (future) modeling:

W. Jacob, K. Krieger, M. Mayer, J. Roth, ***Max-Planck-Institut fuer Plasmaphysik***

D. Rudakov, R. Doerner, R. Moyer ***University of California, San Diego***

P. Stangeby, A. McLean, S. Lisgo ***University of Toronto Institute for Aerospace Studies***

R. Bastasz , J. Whaley ***Sandia National Laboratories, Livermore***

J. Watkins, W. Wampler ***Sandia National Laboratories, Albuquerque***

W. West, C. Wong, N. Brooks, T. Evans, R. LaHaye ***General Atomics***

S. Allen, M.Fenstermacher, M. Groth, C. Lasnier ***Lawrence Livermore National Laboratory***

D. Whyte, ***University of Wisconsin, Madison***

J. Brooks, ***Argonne National Laboratory***

The work is still in progress

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Motivation: Tritium retention issue

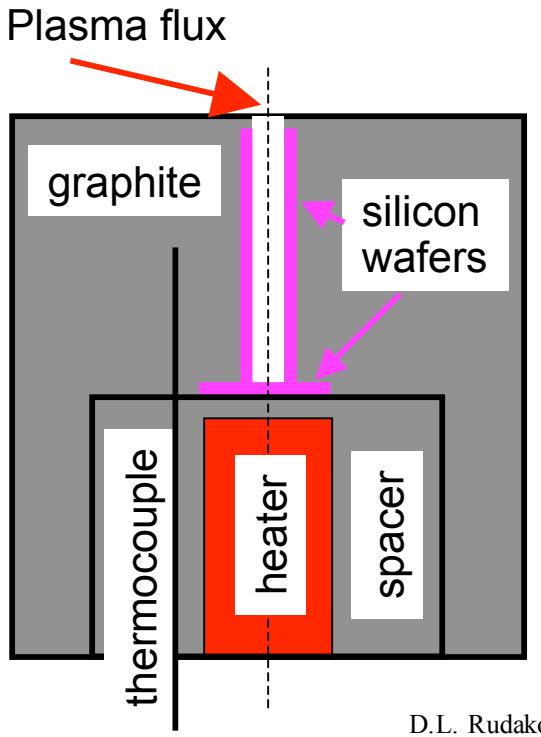
- Tritium co-deposition/retention is one of the most critical issues for ITER
- One of the most troublesome carbon deposition regions for trapping tritium are the narrow tile gaps since such regions are not accessible to many of the proposed T-recovery methods
- These deposits tend to be the "soft", H/D/T-rich hydrocarbon layers, rather than the "hard", leaner layers that occur on plasma-contacting surfaces
- Fortunately, such soft deposits appear to be much more manipulable than hard ones, and it may be possible to control or prevent the formation of such deposits by altering the graphite temperature

Experimental Concept

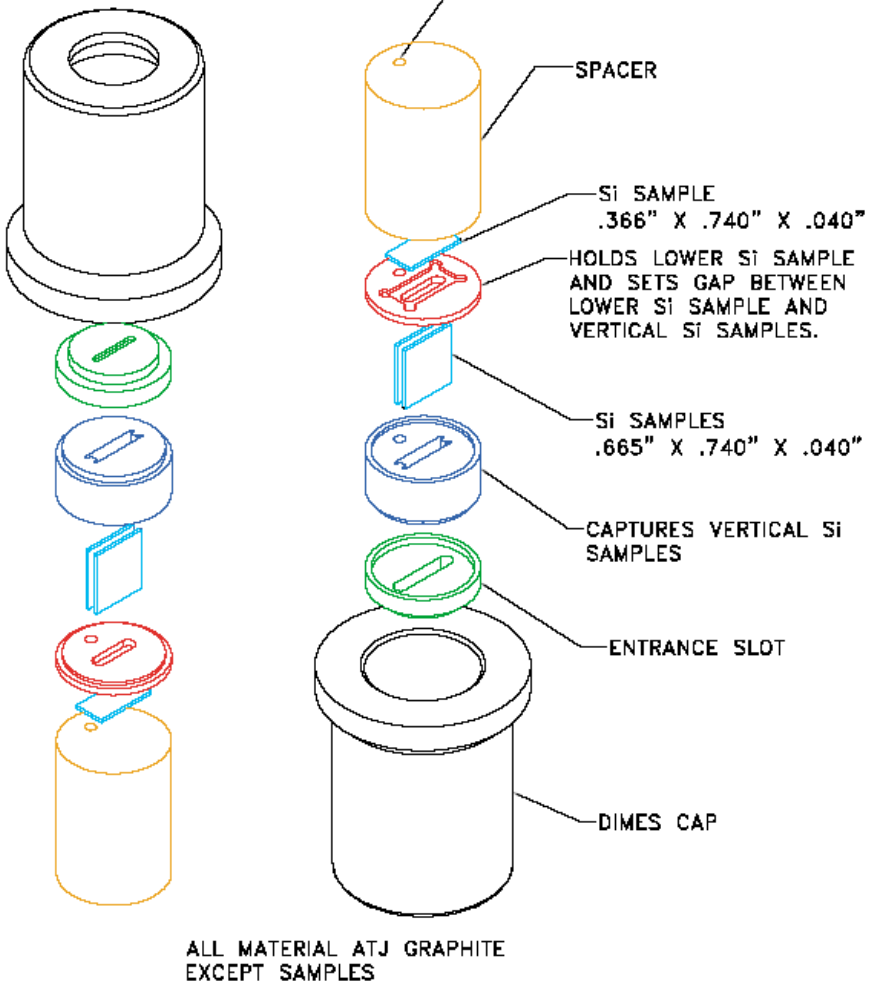
- In DIII-D co-deposition of deuterium (as a proxy for tritium) can be studied in a simulated tile gap using DiMES
- Two separate exposures, one at ambient temperature and one at 200ºC have been proposed to assess the temperature effect.

Concept features:

- strike point close to entrance slit
- defined geometry for modeling of the deposition profile
- deposition on the silicon side wafers
- silicon bottom plate (additional deposition monitor)
- heater and thermocouple required for the second exposure

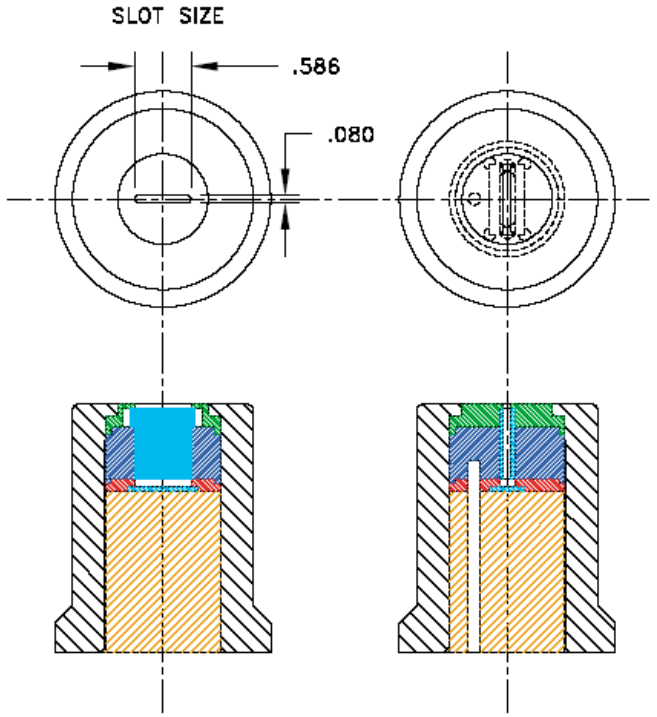


Actual design of the DiMES tile gap sample (non-heated)



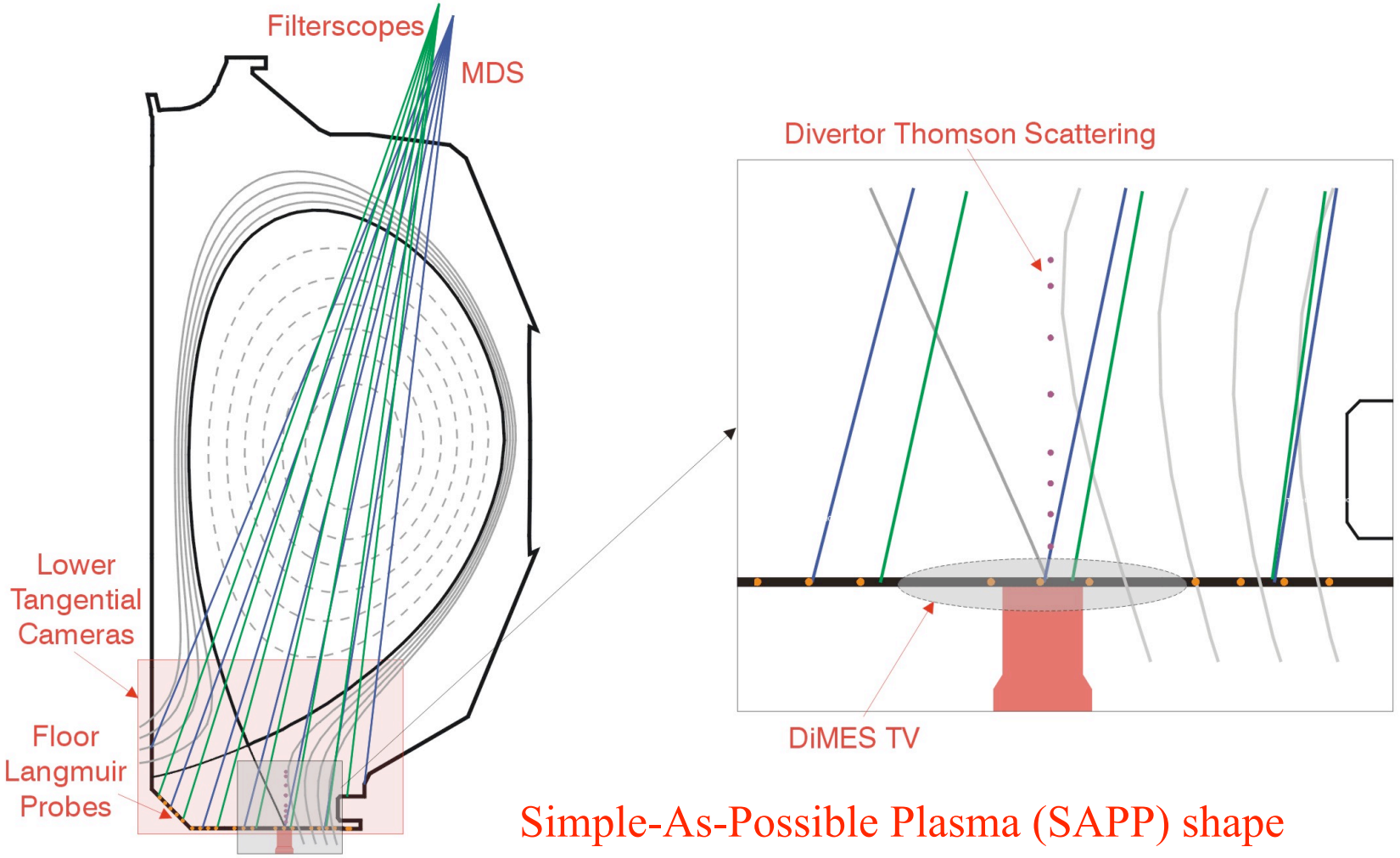
DiMES #122
Version A
2004 Feb 3

JW & RB - SNL/CA



Courtesy of J. Whaley and R. Bastasz

Experimental arrangement on DIII-D



Simple-As-Possible Plasma (SAPP) shape

Not shown but also there: IR TV, tangential mid-plane camera, CER, CO2 interferometers, ASDEX gages, reciprocating probes, SPRED, etc.

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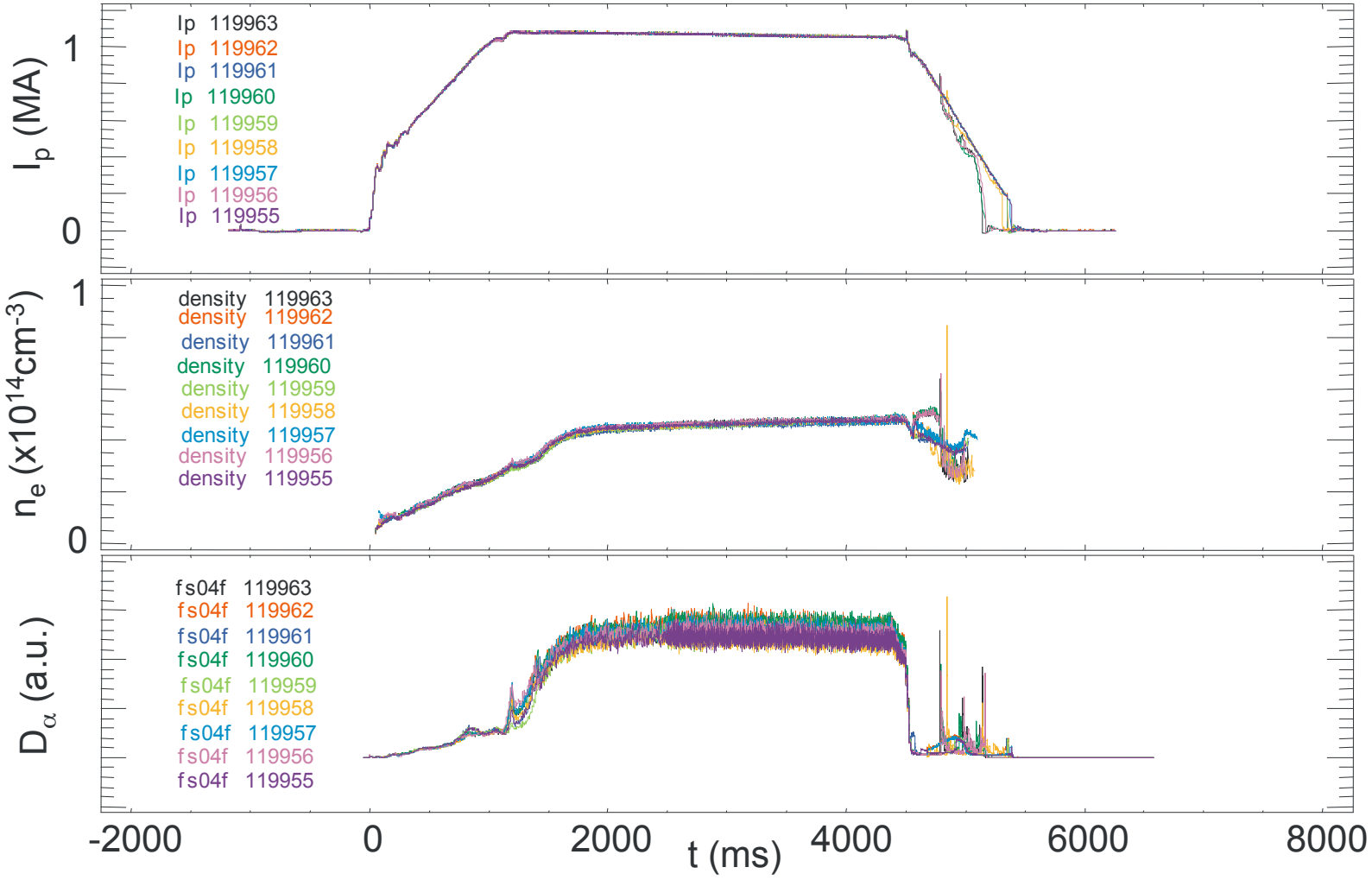
First exposure: no heating



9 highly reproducible LSN SAPP L mode shots

Total exposure time of about 32 sec

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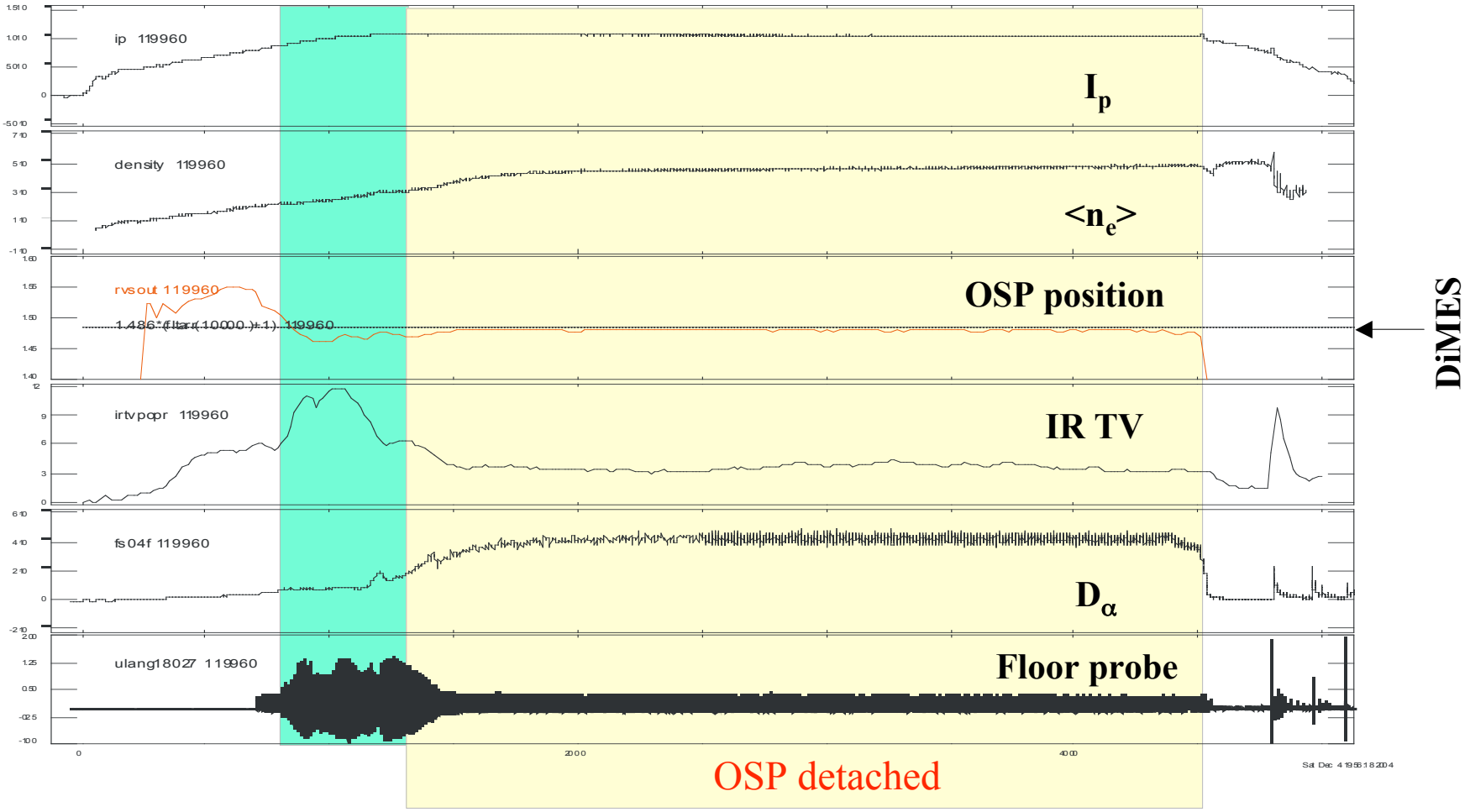
Shots were high-density, with OSP detached most of the time



- High-density L-mode $\langle n_e \rangle = 4.5 \times 10^{13} cm^{-3}$
- OSP on DiMES from 0.8 to 4.5 sec
- Short attached phase from 0.8 to ~ 1.2 sec
- Detached after 1.2 sec

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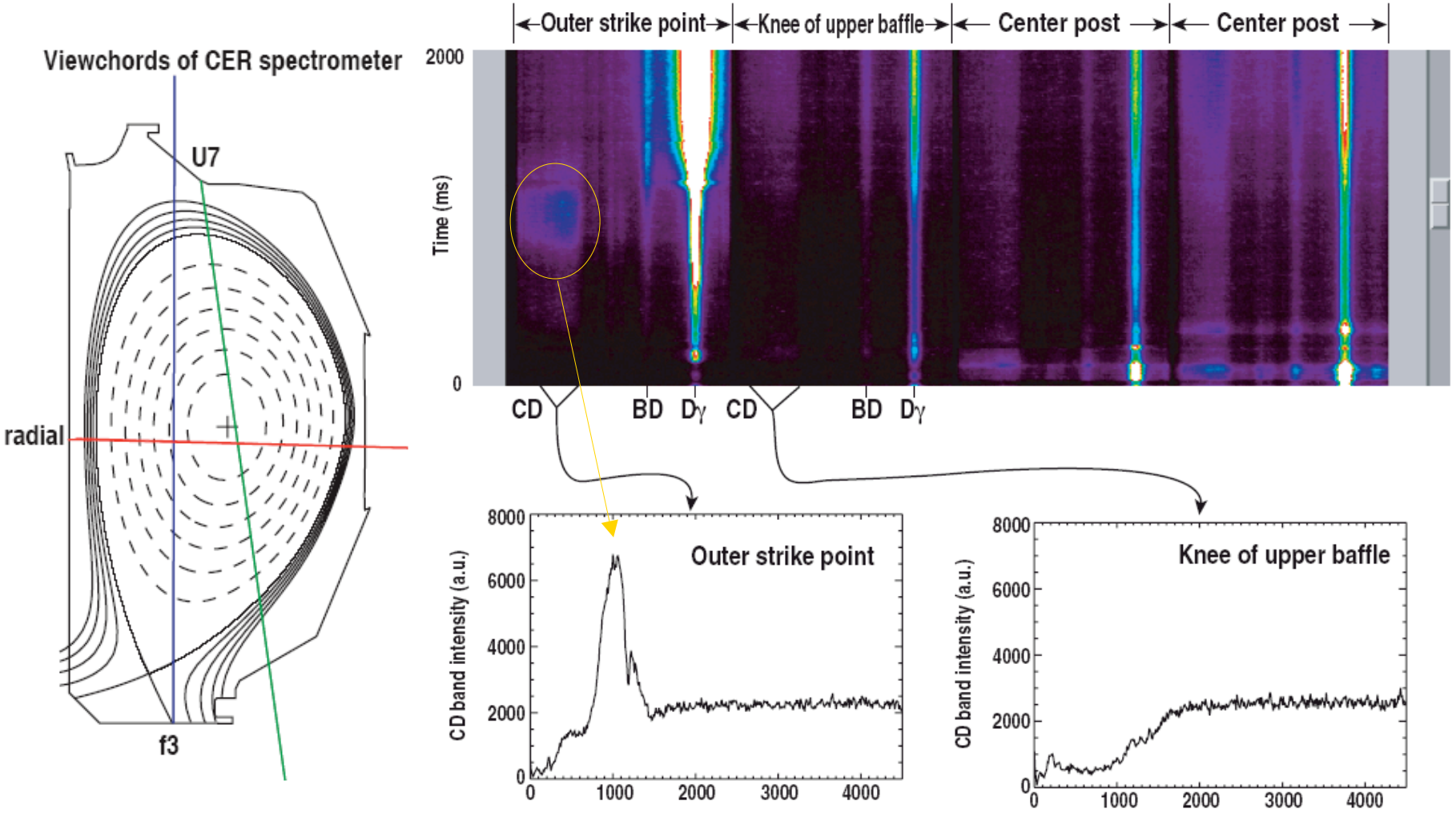
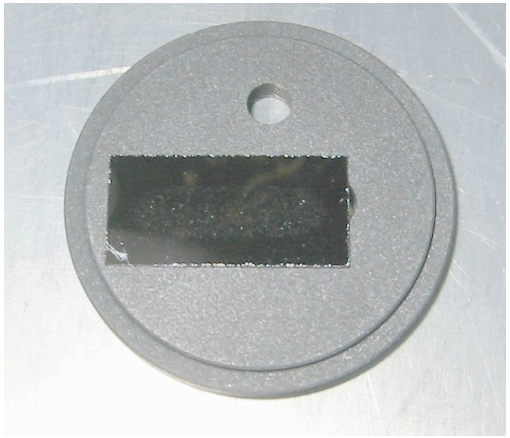
CER spectrometer saw CD band during the attached phase



Courtesy of N. Brooks

There were visible signs of plasma contact on the sample face upon removal



There also appeared to be some visible deposits on the bottom Si catcher plate

Are those deposits?

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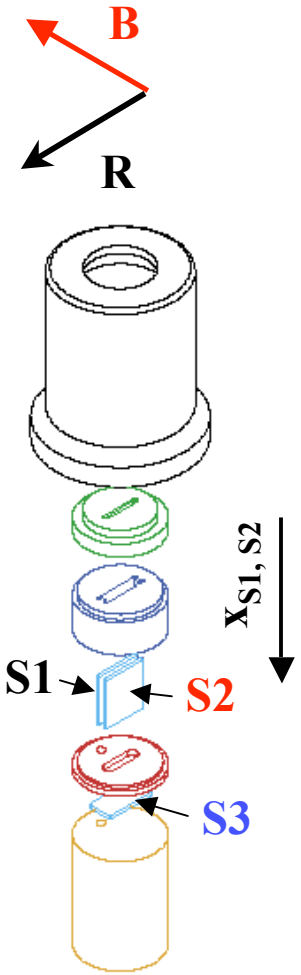
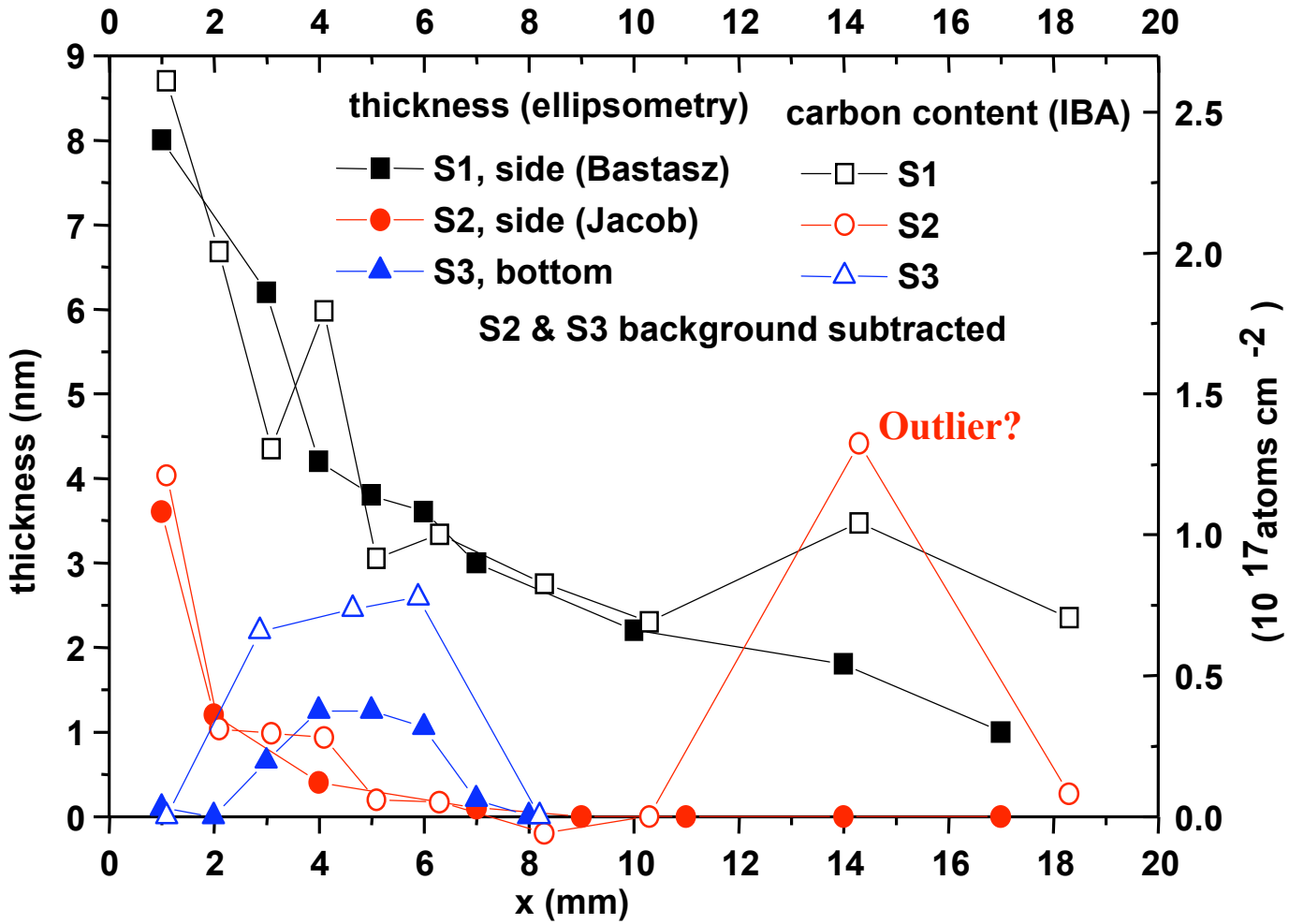
Initial analysis results from the first exposure

- Initial analysis of C deposition and D co-deposition on Si inserts from the exposed sample has been performed at Max Planck IPP, Garching
- Both ion beam analysis (IBA) and ellipsometry have been completed
- Both methods indicate films on all three Si wafers are of the "soft" amorphous carbon type
- Measured D/C atomic ratio is 0.3 – 0.6

Comparison of C deposition thickness by ellipsometry and IBA

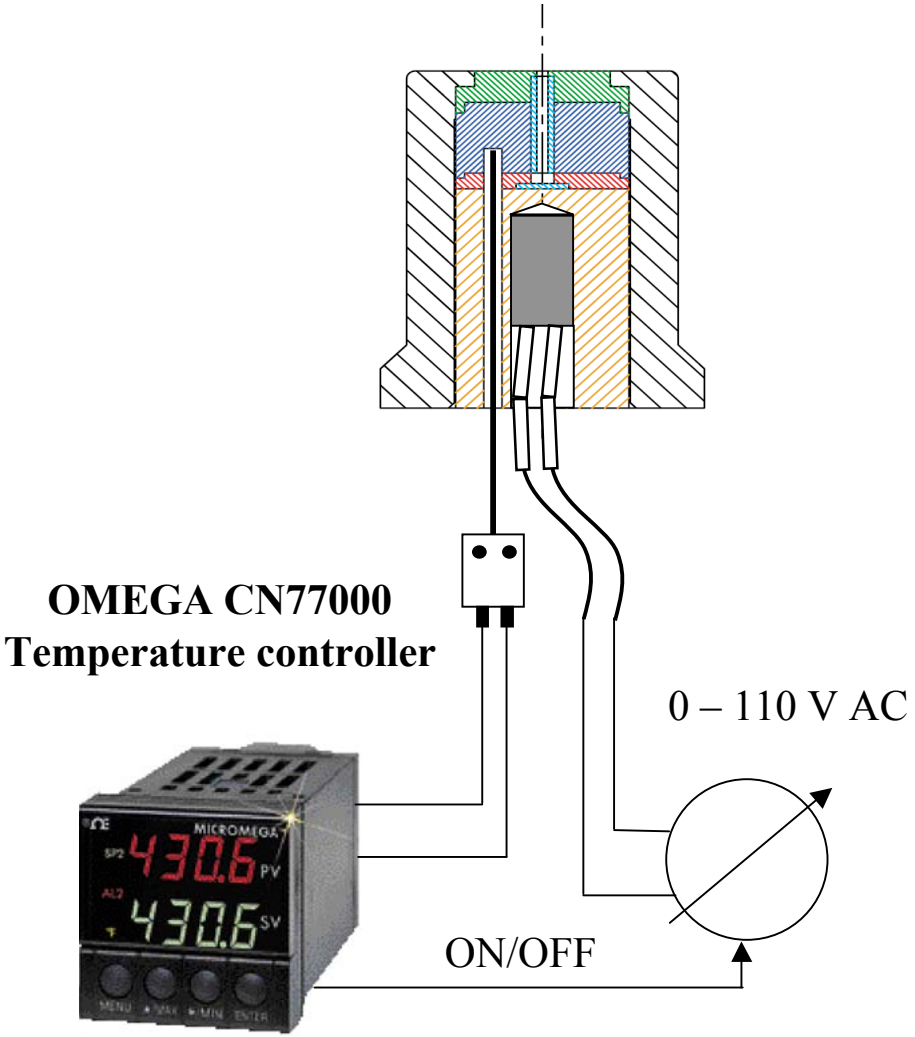




In general good agreement of the relative shapes
Absolute values of both methods have to be checked

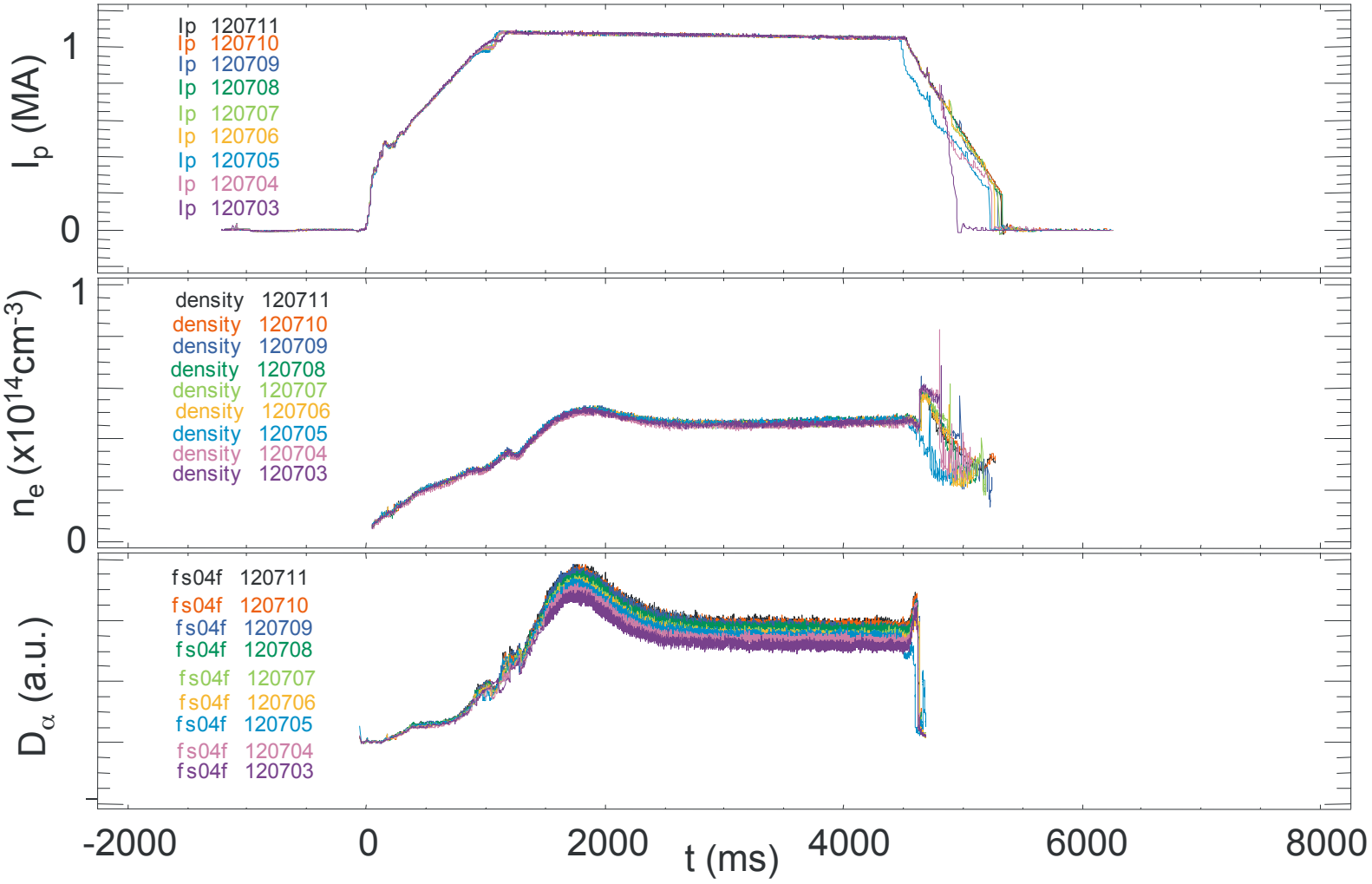
courtesy of W. Jacob and K. Krieger

Second phase: heated exposure



- Heater and thermocouple built in the sample
- In situ temperature control established
- A depth-marked Si button built in the sample face to measure surface erosion/deposition

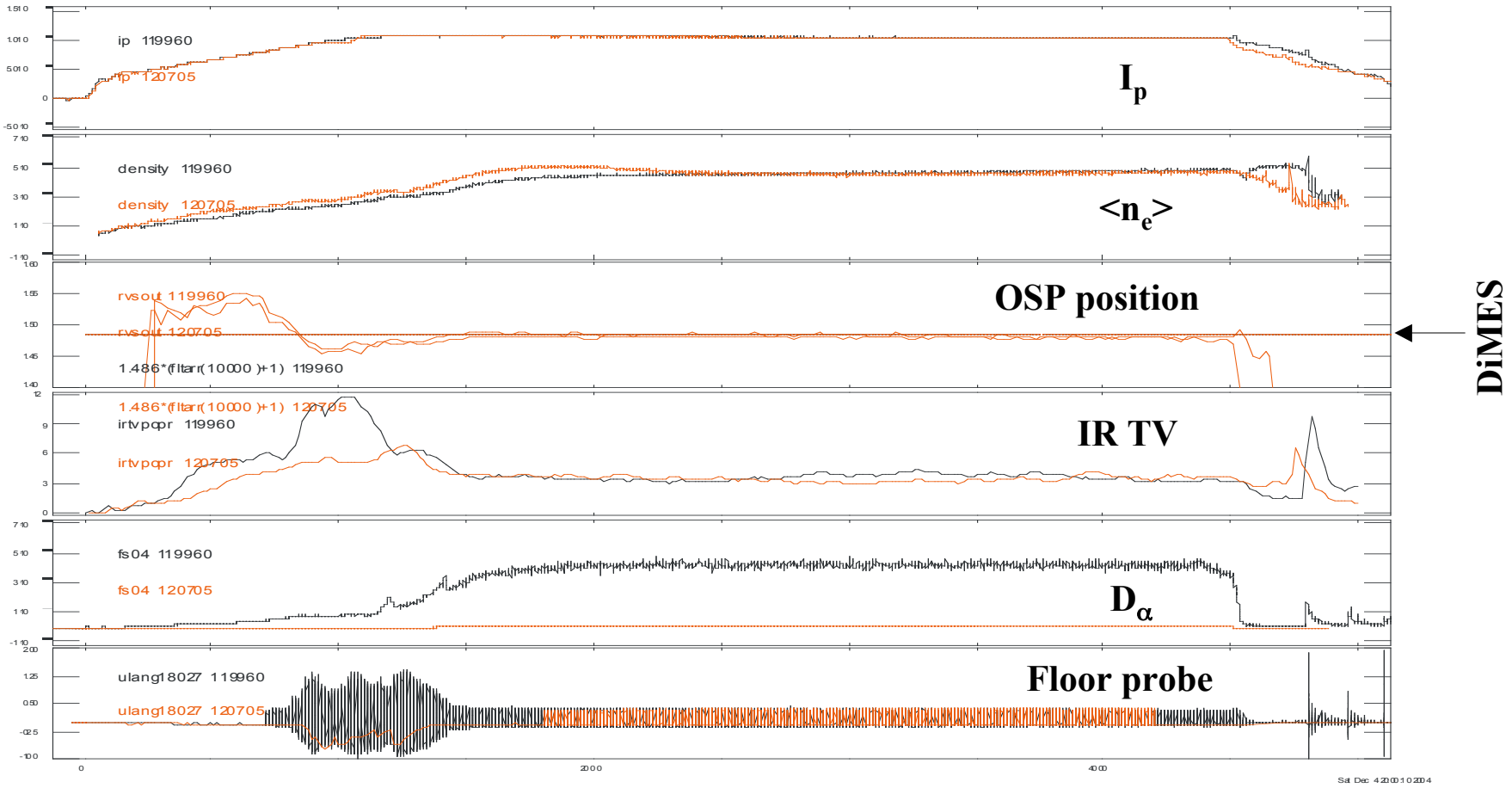
Second exposure: with heating



9 highly reproducible LSN SAPP shots again

Total exposure time about same as before

Plasma conditions were very close in the two exposures



First – non-heated

Second – heated

No attached phase in the second exposure!

No visible signs of plasma contact on the sample face upon removal

Is it because there was no attached phase or because the sample was hot?

Where are the deposits from the previous exposure (not visible, wiped off, eroded)?

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Initial analysis results

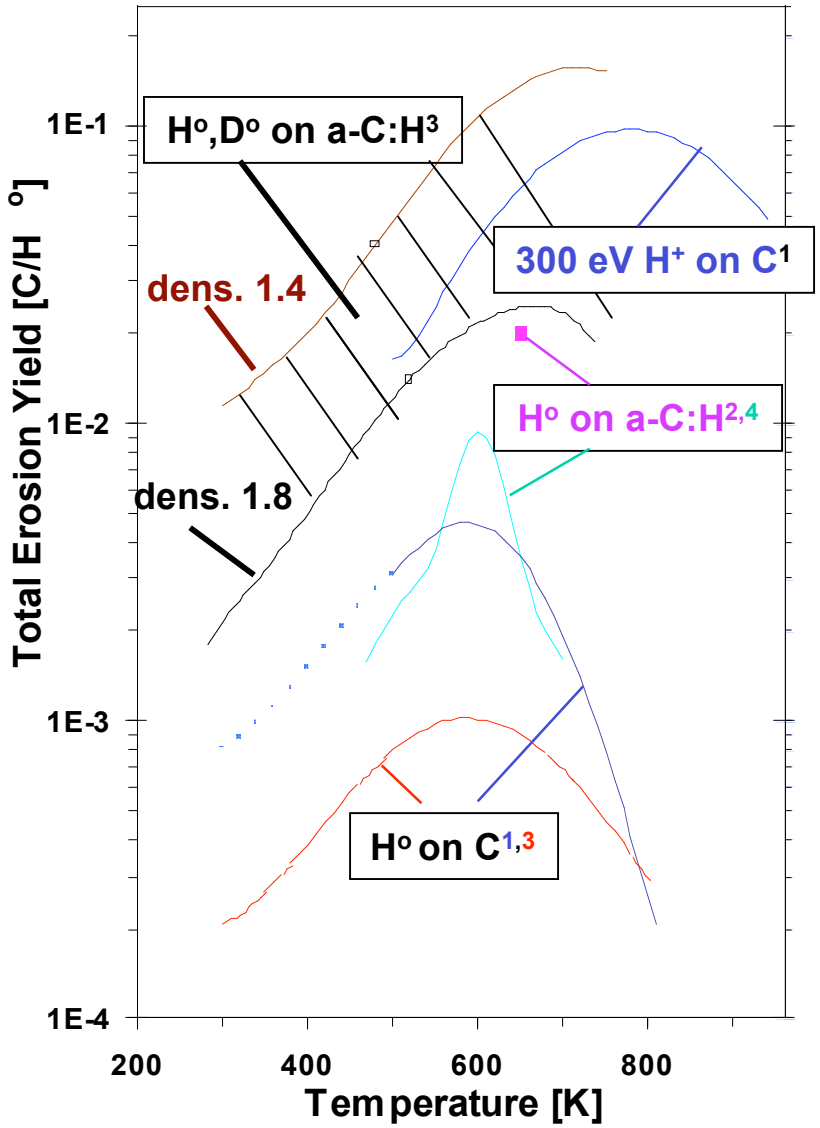
- Carbon deposition and D co-deposition measurements are not yet available
  Accelerator at MPIPP is down but will be available soon

- **There is a surprise result already: IBA analysis of the depth-marked button performed at SNL Albuquerque by W. Wampler showed total net erosion of about 95 nm, corresponding to about 3 nm/sec**
  The results were double-checked versus unexposed sister button and confirmed

- This is in contradiction with previous DiMES measurements in detached H-more discharges that indicated net carbon deposition near the OSP
  Whyte et al., Nucl. Fusion 41 (2001) 1243

Can the difference be resulted by the elevated surface temperature?

Can measured erosion be due to enhanced chemical erosion?



- Chemical erosion rates have strong temperature dependence
- If chemical erosion was indeed enhanced, there should have been some spectroscopic evidence
- According to N. Brooks and A. McLean, MDS data indicated slightly increased CD band intensity in the heated exposure
- D. White has found no indication of increased CD or CII intensity

The question is still open

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Figure from V. Philipps's ITPA talk

Summary

- We successfully completed two exposures of the Tile Gap DiMES sample, at ambient temperature and at 200°C
- Initial analysis of C deposition and D co-deposition from the first (non-heated) exposure has been completed
- Results on C deposition and D co-deposition from the second (heated) exposure will be available soon
- Measured surface erosion rates from the second exposure are yet to be explained
- We have extensive set of diagnostic data for these discharges and we hope they will be modeled

Let's revisit this during the discussion!

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